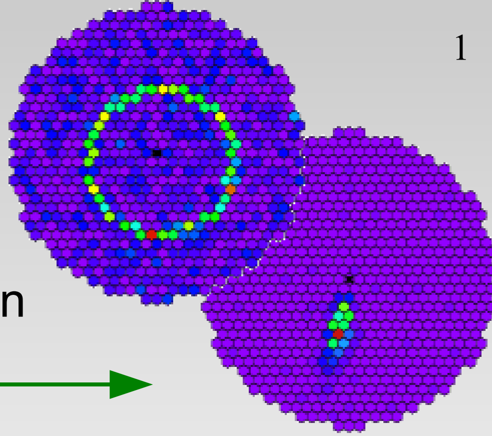
CERES

Camera **E**lectronics and **RE**flector **S**imulation



- Why Ceres? Ceres for MAGIC and Dwarf.
- What is the status of Ceres?
- What is missing?
- What can you do? Who is doing what?

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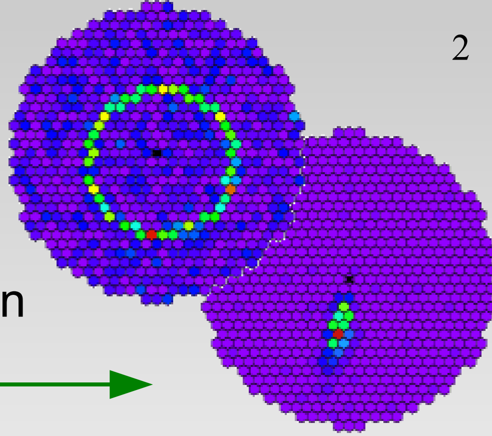

Why Ceres?

- The MAGIC Monte Carlo Programs (here called MMCS) are partly over 10 years old.
- These programs are written in C (straight forward without any structure)
- They are simply a mess.

  - ➔ These programs are not flexible
  - ➔ It is really difficult to understand them and implement new stuff.

What do we want?

- Programs easy to enhance
- Programs easy to use
- A single concept for all programs
  - ➢ MARS

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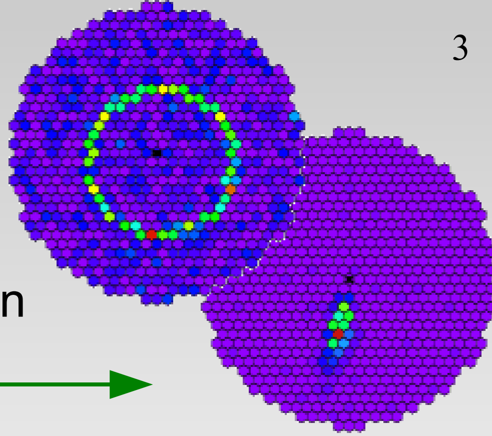

For DWARF...

- It is easier and faster to re-write the code, because
  - it is easier and faster to debug it
  - we need flexible Monte Carlo programs anyway
  - we don’t want to be dependent on the MAGIC software development
    - ➢ CERES is a new development which has almost nothing to do with the existing MAGIC Monte Carlo programs
- What can we do?
  - Crosscheck the MAGIC Monte Carlo programs with ours...
  - Crosscheck ours with the MAGIC Monte Carlo programs...

... implementing MAGIC (just by resource files).

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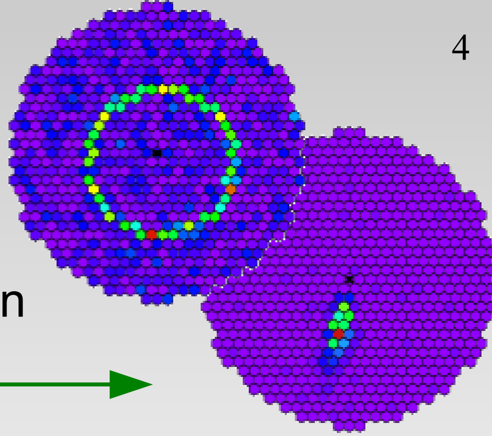

- Still in development...
  - most new features can easily be implemented
  - don’t hesitate to ask

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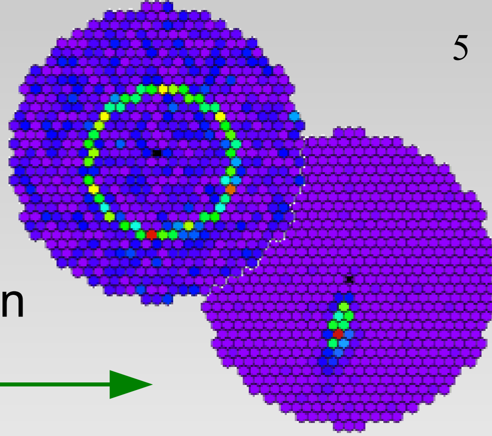

Input/Output

- Input:
  - Reading of Corsika cer-files (MMCS and raw Corsika)
  - EventIO coming soon
  - The setup (as atmosphere) is read as much as possible from the Corsika file

- Output:
  - Reflector files (Ceres format, root-files)
  - Camera files (MAGIC/MARS format)
  - Image files (signal without noise, star-format)

- Format
  - The headers used in MARS so far are a mess coming form the old Simulation (most of the containers are just storing the MMCS setup anyway)
  - Currently Ceres copies the new header info into the old structure
  - In the future we will do it vice versa

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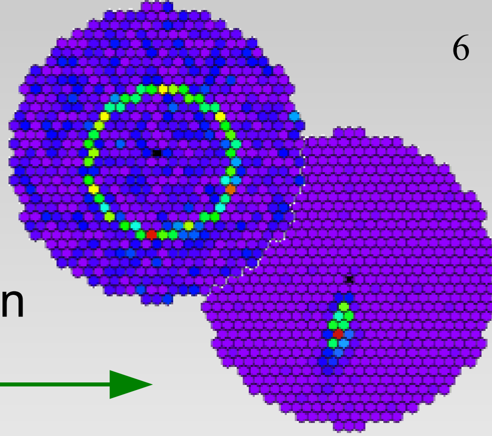
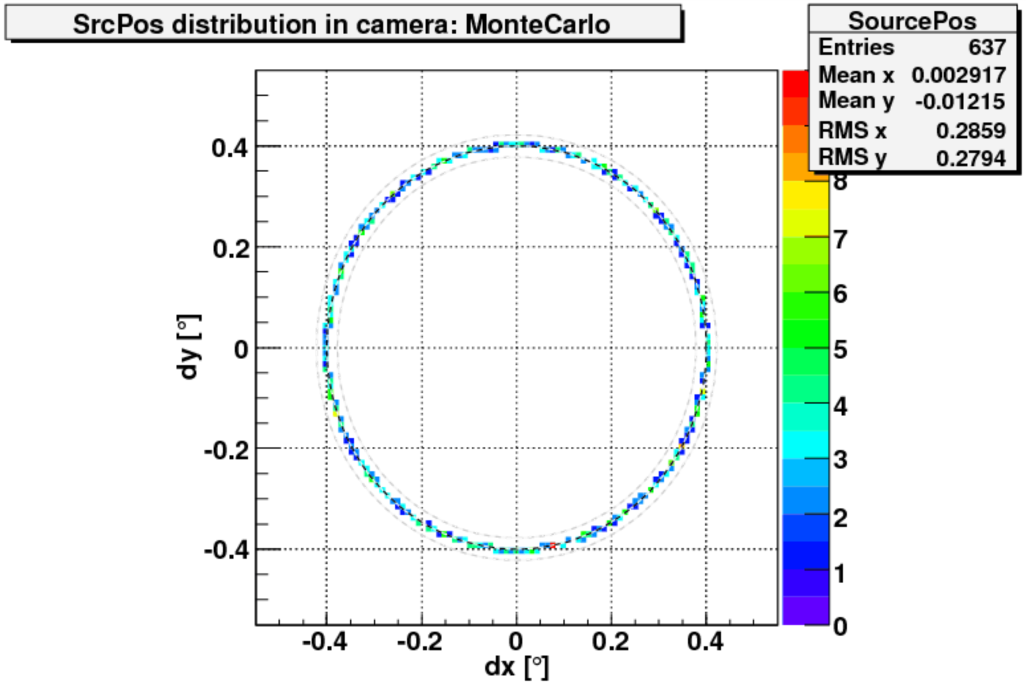


Pointing

- The magnetic field is correctly taken into account (Inclination and Position of magnet. North)

- The pointing is either
  - fixed on-target
  - fixed off-target
  - randomly distributed, fixed distance
  - ...



Atmosphere

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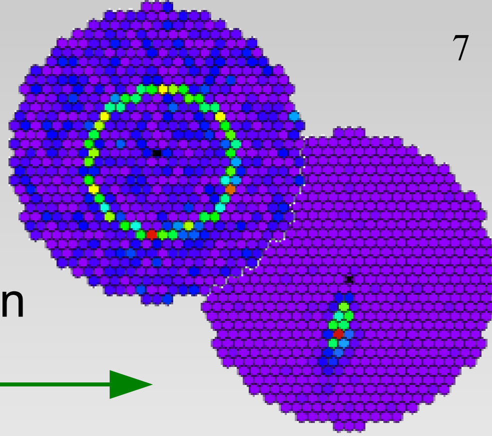
Camera Electronics and REflector Simulation

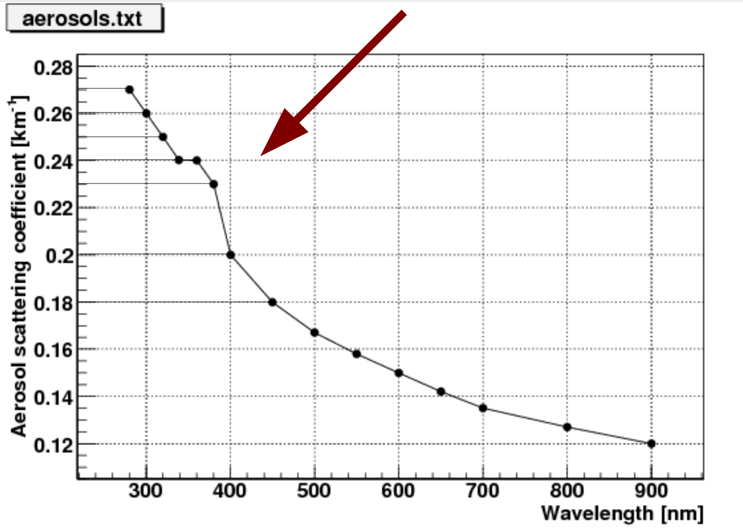


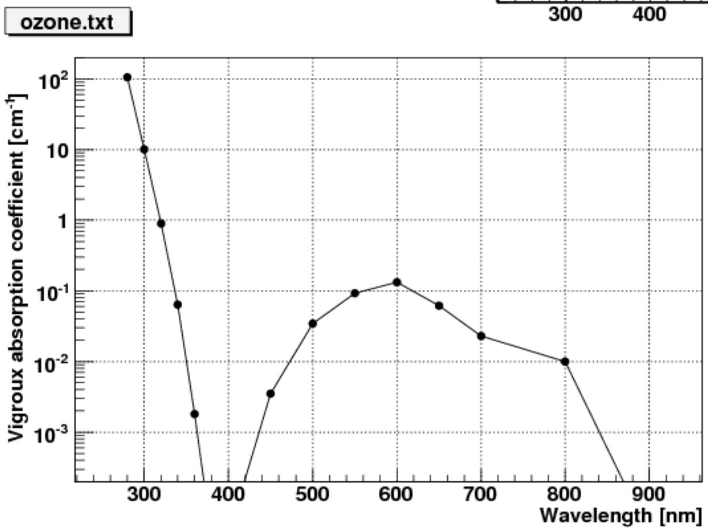
Rounding artefact?

- Rayleigh
- Ozone
- Mie (Aerosols)

- Code taken from MMCS (atm.c, attenu.c)
- Wavelength dependent
- Structured and some improvements
- Crosschecked with the original code (identical results within 10^{-10})

- Would like to use spline interpolation...





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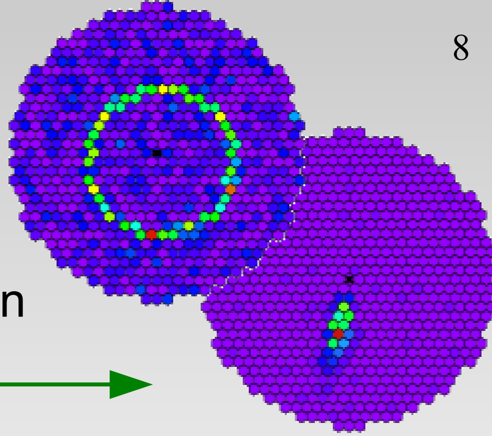
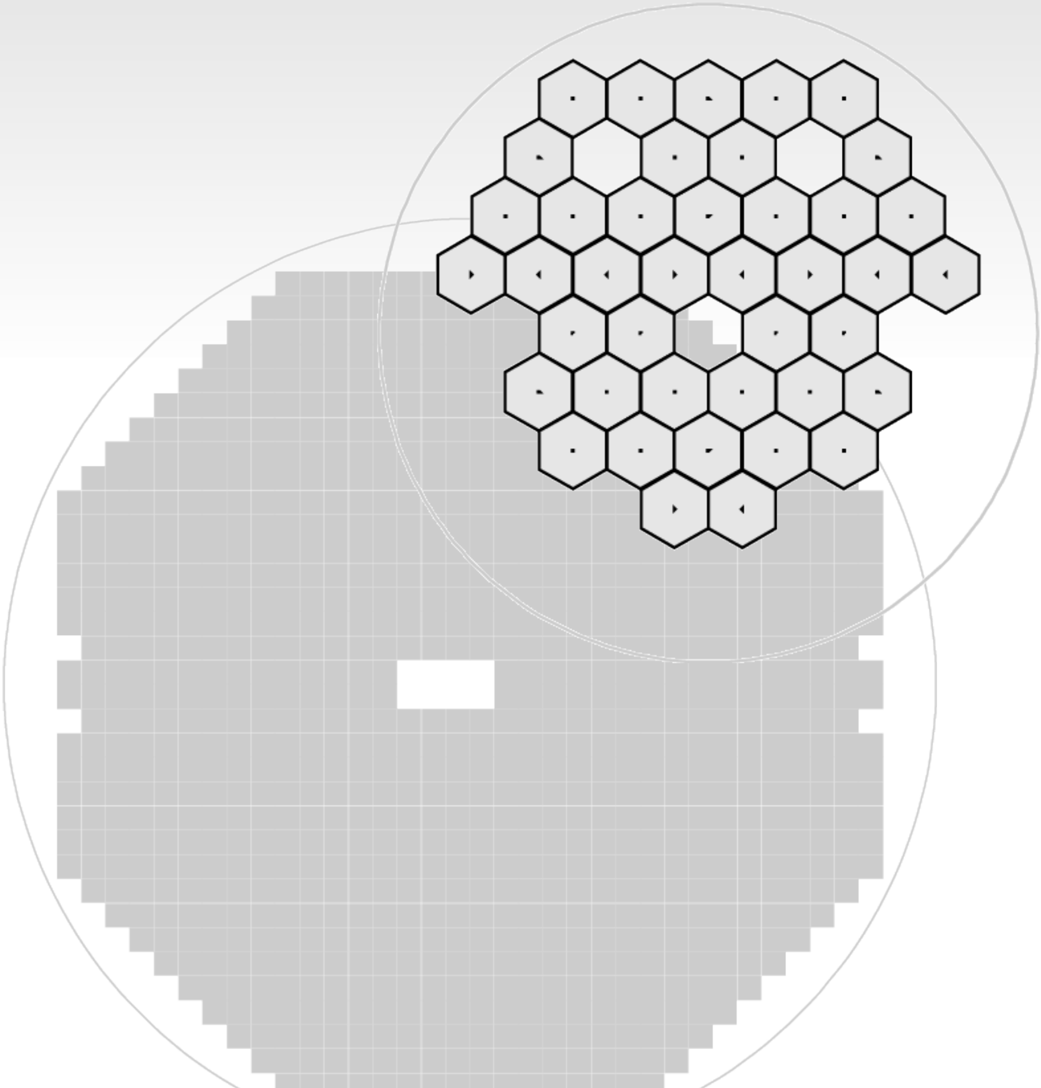


Reflector

- Layout stored in file
- In principle any mirror-shape possible (if a proper class describing the geometry is implemented)
- So far all individual mirrors are spherical
- The incident point is calculated analytically
- PSF implemented by random smearing of the normal vector at the photon incident point



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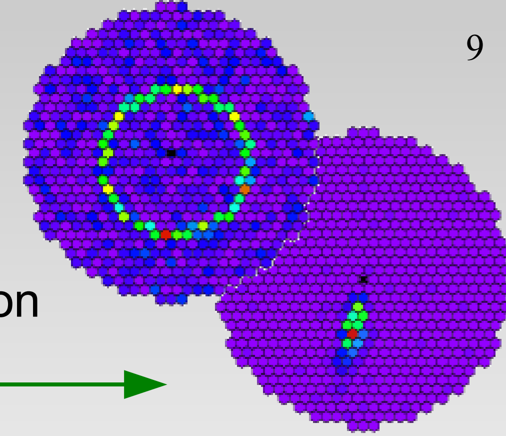
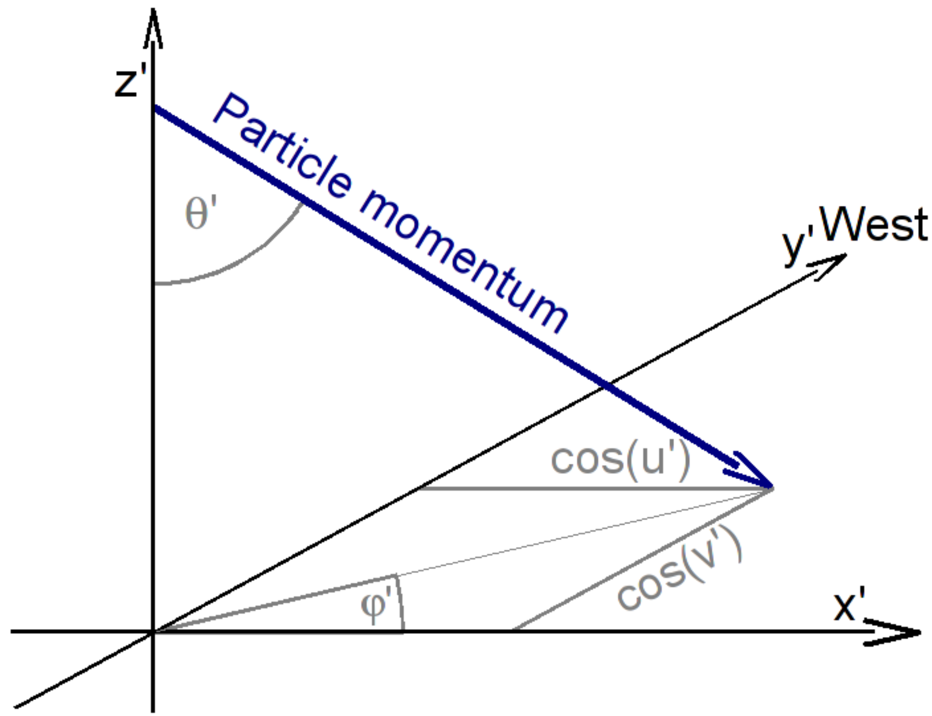
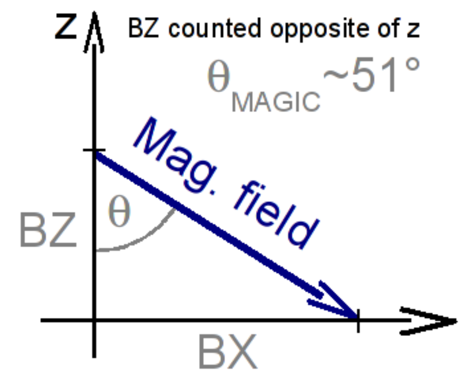


CORSIKA Coordinate System





Northern hemisphere
Magnetic North φ'=0
Magnet Southpole

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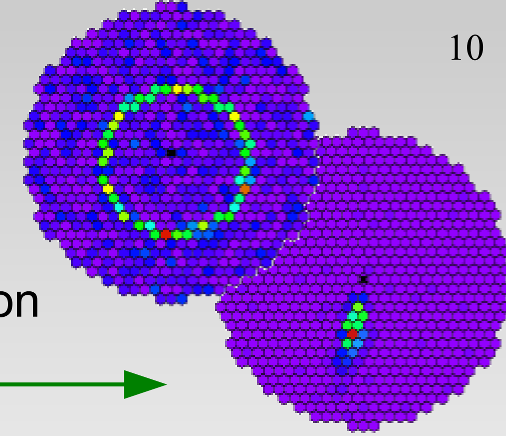
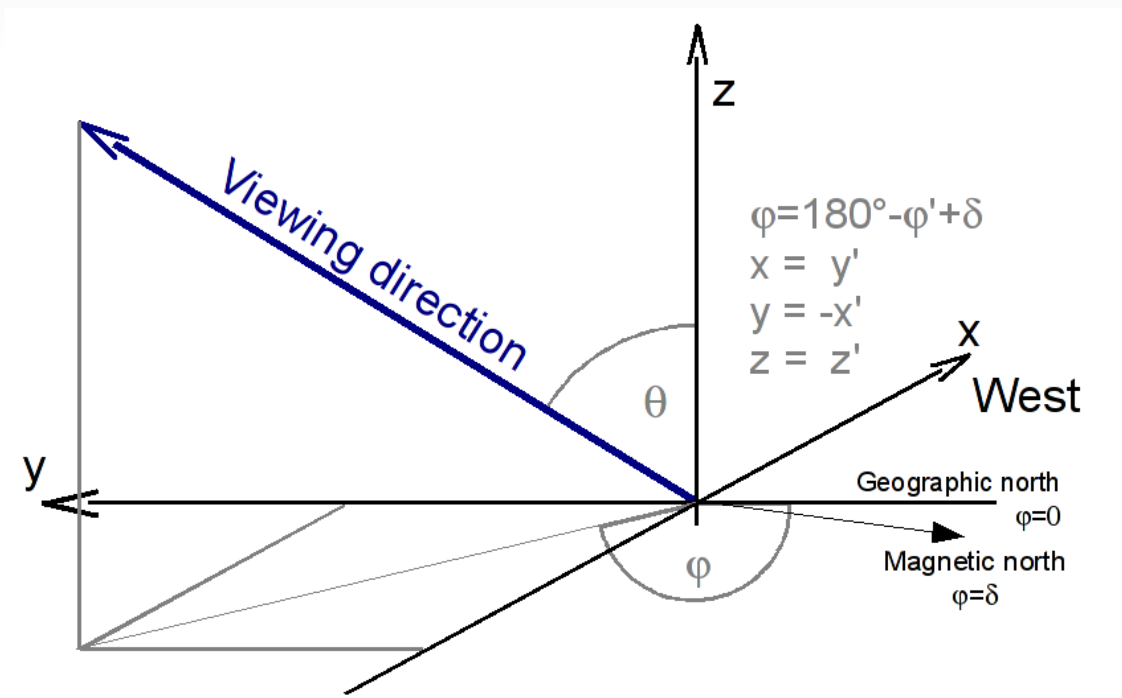
Camera **E**lectronics and **RE**flector **S**imulation



Ceres Coordinate System

- transformation done when reading



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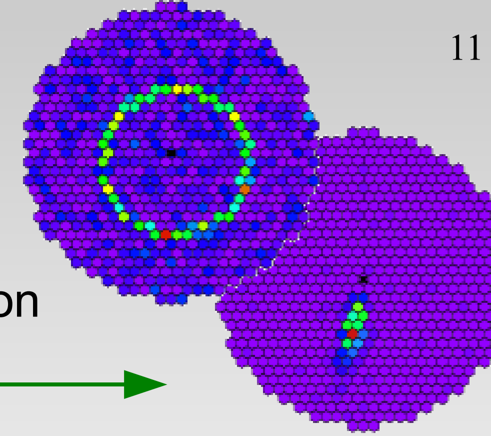
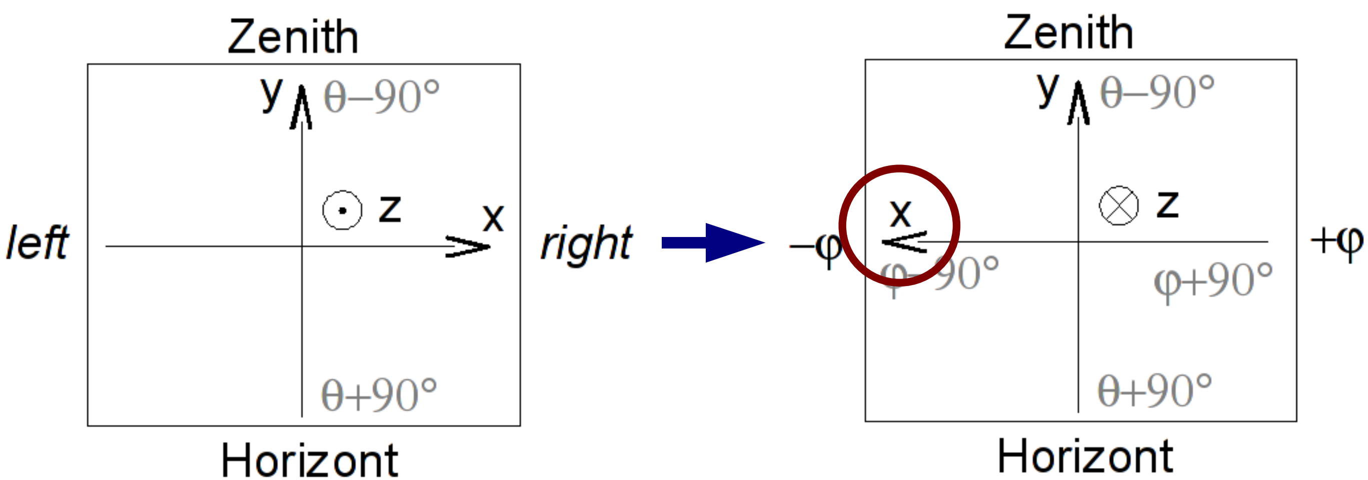
Camera **E**lectronics and **RE**flector **S**imulation



View
from the camera to the reflector
(Ceres coordinate system)

View
from the reflector to the camera
(Ceres coordinate system)



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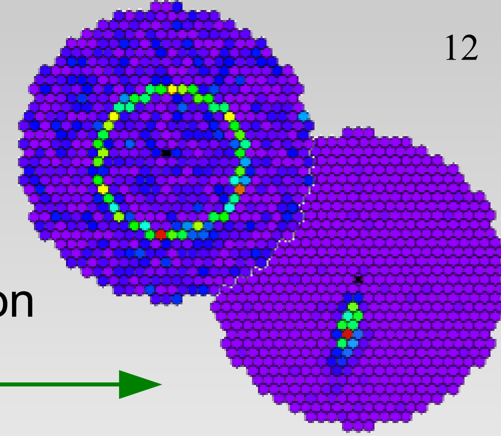
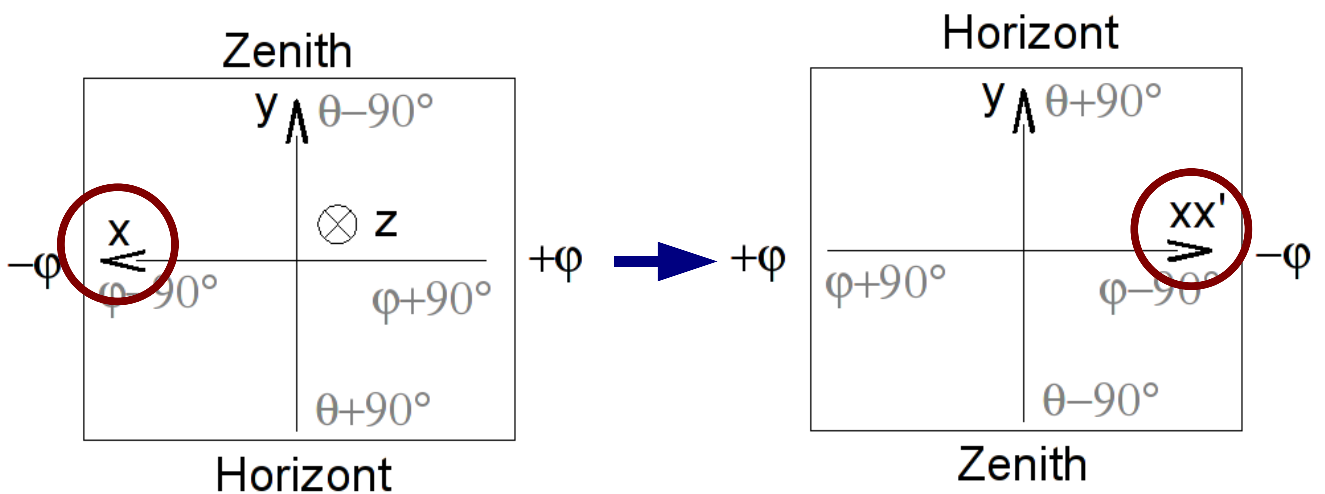
Camera **E**lectronics and **RE**flector **S**imulation



View
from the reflector to the camera
(Ceres coordinate system)

View
from the reflector to the camera
(Camera coordinate system)



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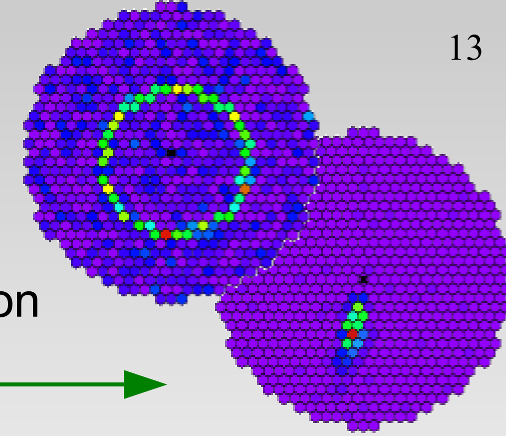
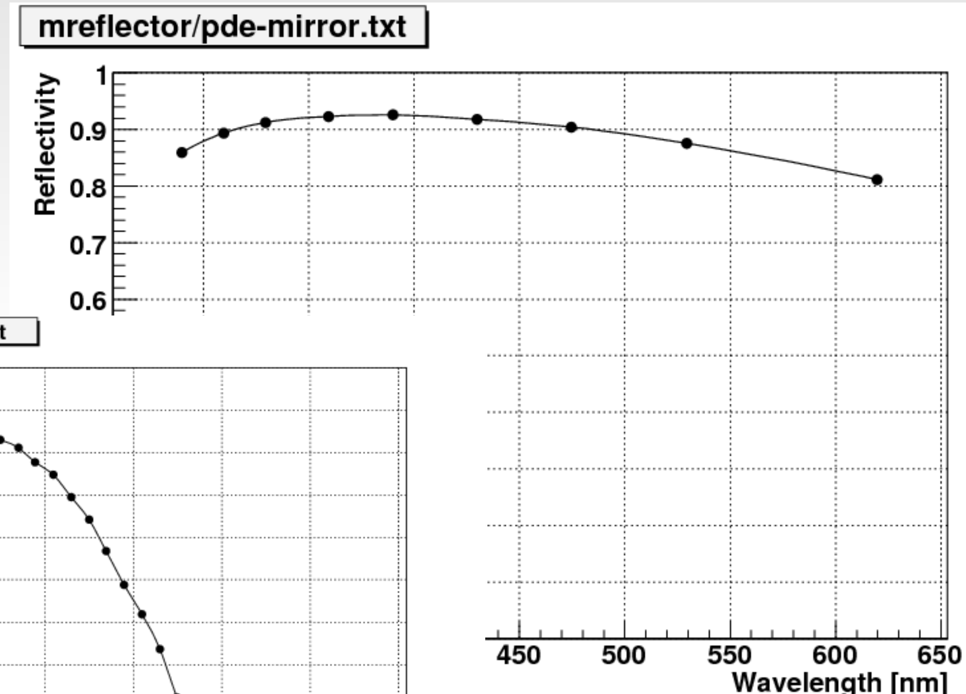
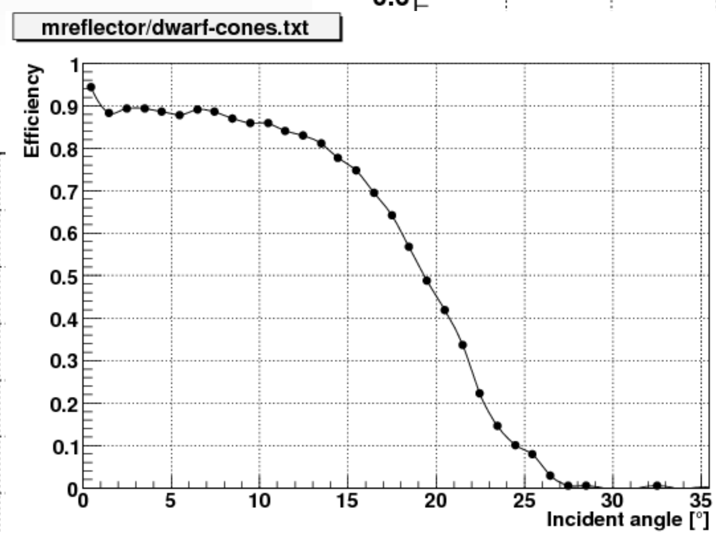
Camera Electronics and REflector Simulation

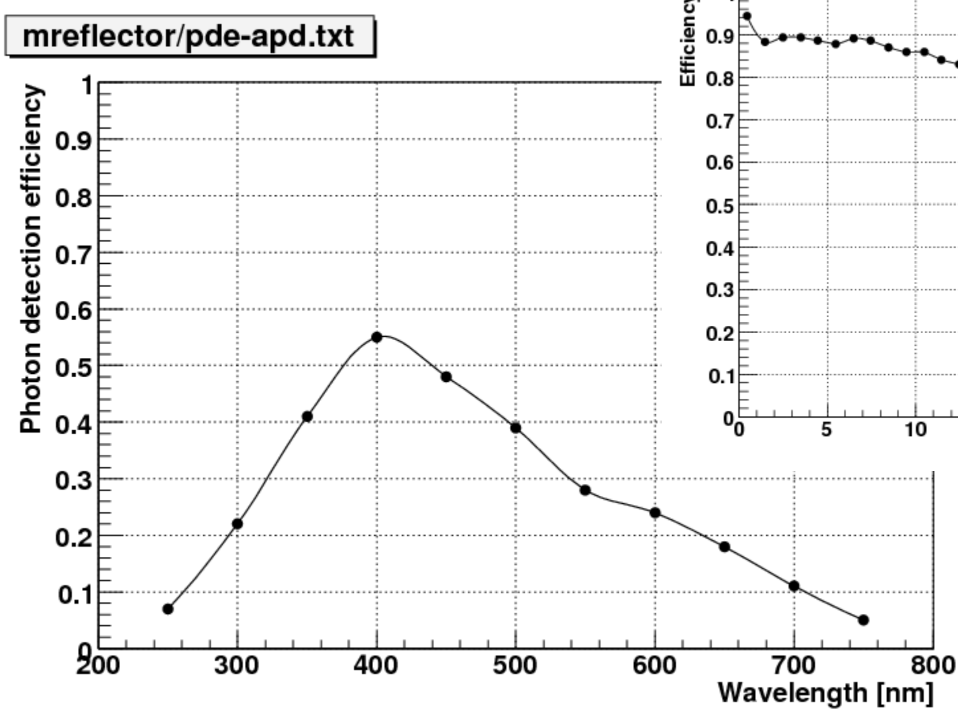


Efficiencies

- Read from files
- Interpolated using a third order spline







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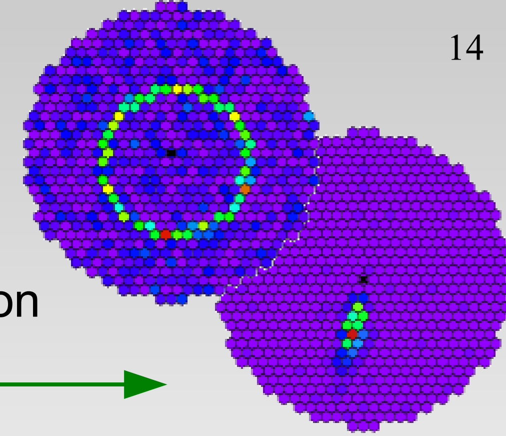
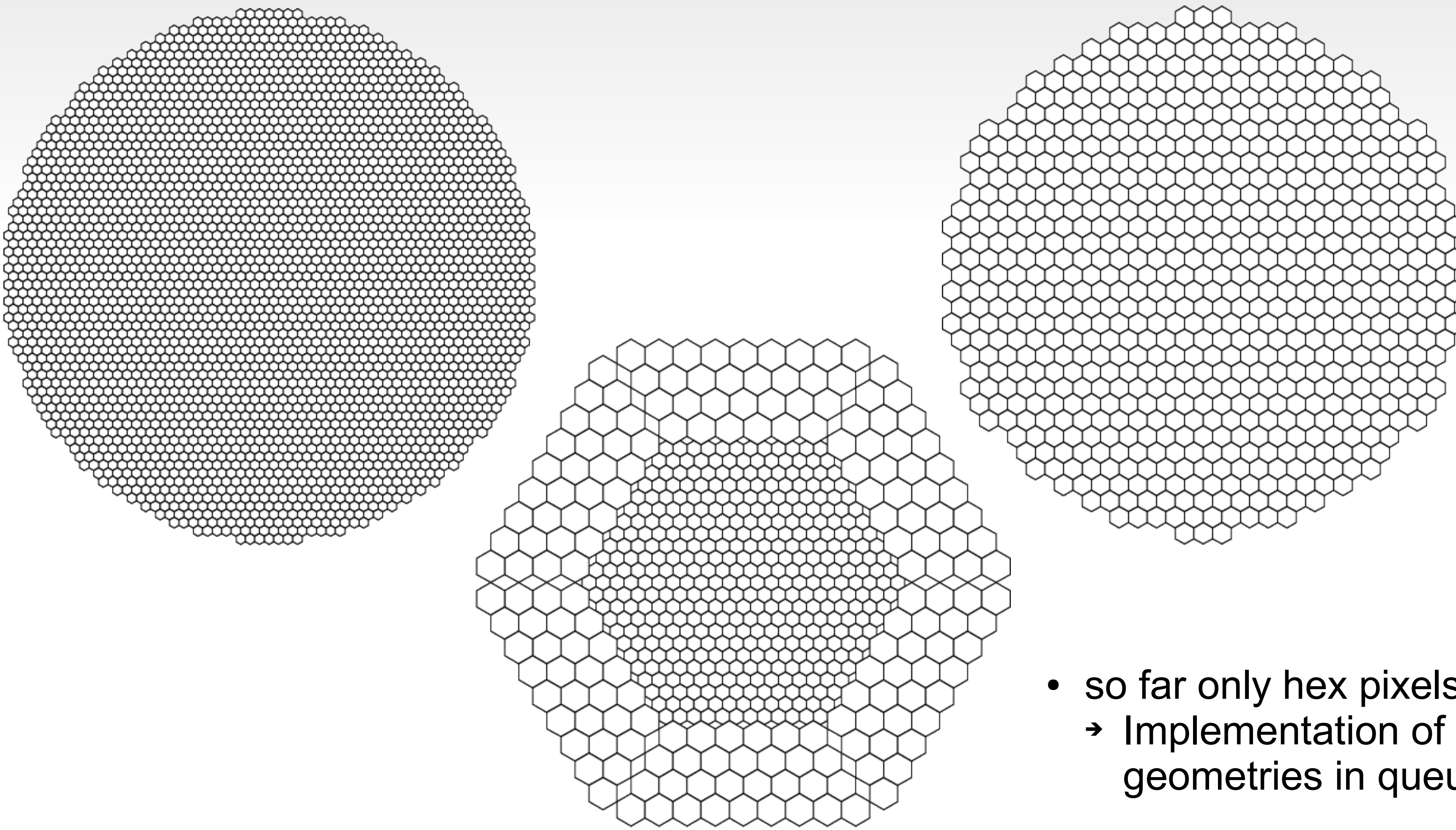
Camera **E**lectronics and **RE**flector **S**imulation



User-defined cone geometries



- so far only hex pixels
  → Implementation of other geometries in queue

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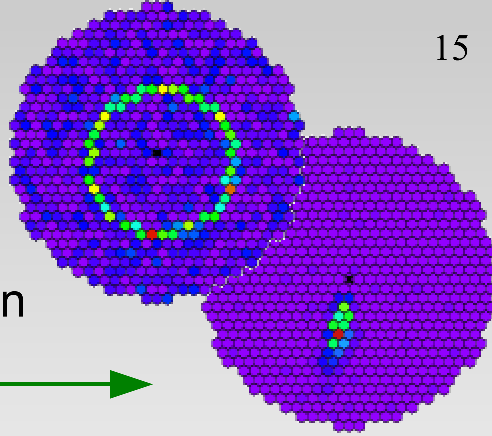

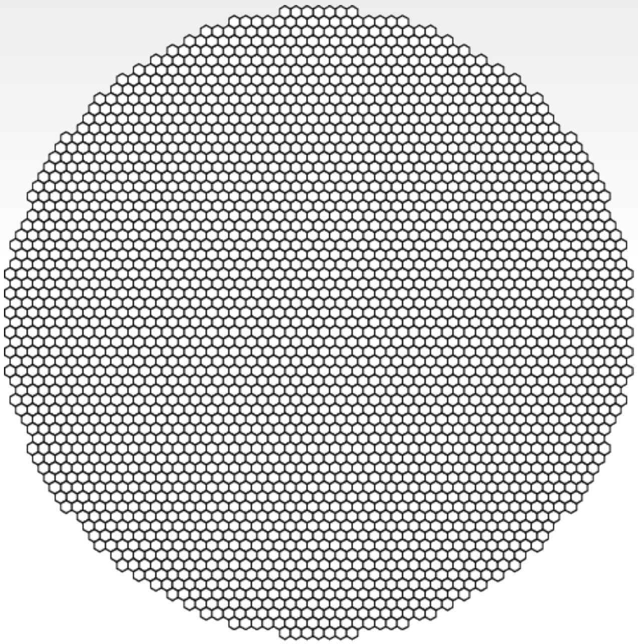

Cone geometry

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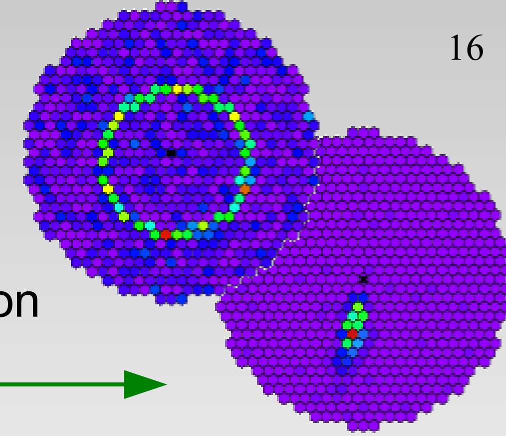
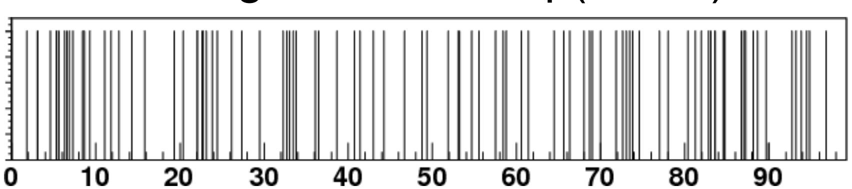


NSB simulation

- exponential distance between two NSB photons
- NSB photons hitting the cone are simulated
- So far you must know the rate with which nsb photons hit your cone (taking into account all efficiencies (including the APD)
- So far the rate is identical for all pixels (scaled with the pixel size w.r.t. To pixel with index 0 to support the outer MAGIC pixels)
- The APD dark current is simulated as addition fixed rate per *cone* not scaled with the pixel size

```
T += gRandom->Exp(1/rate)
```



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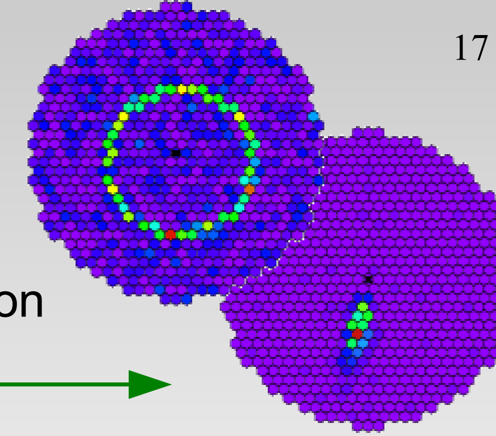


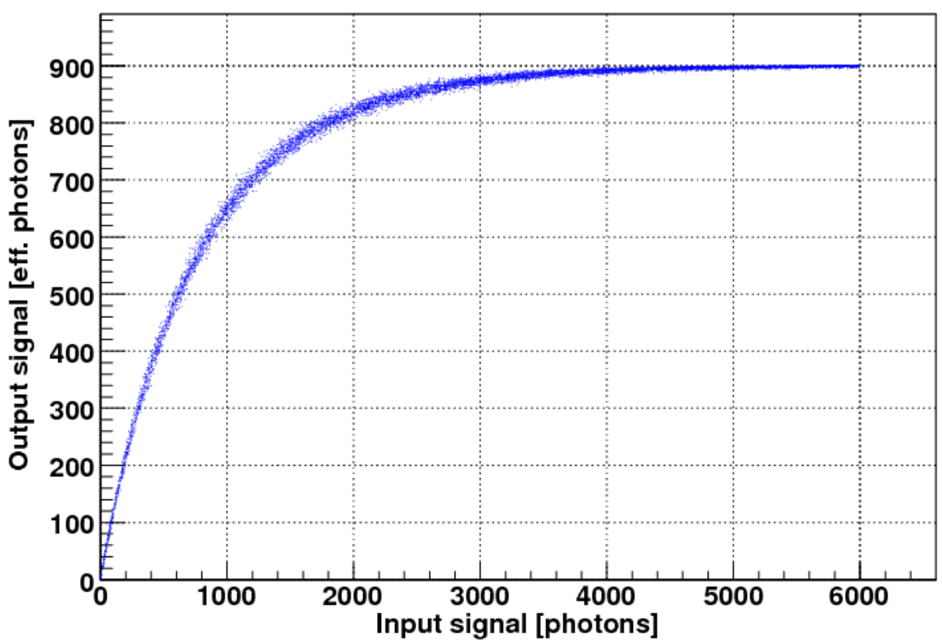
APD simulation

- flexible cell number, square layout
- cell-dead time
- cell recovery
- Crosstalk

- The APD is initialized at the beginning of the event with a random exponentially distributed *last time of hit per cell.*
- But every *hit* is fully simulated (takes crosstalk into account)
- I think this doesn't include the dead time very well.
- It is slow.
- So far the rate of initialization is just the NSB rate of pixel 0 (no dark current, no size dependancy)

Additional Noise (Excess noise?)

- Each APD-signal is smeared with a gaussian with $\sigma = p\cdot\sqrt{signal}$ (currently p=0.2)



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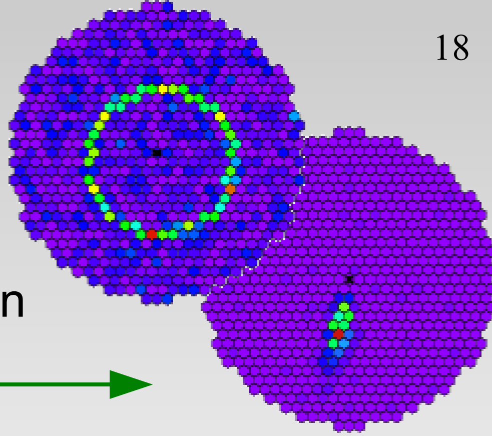
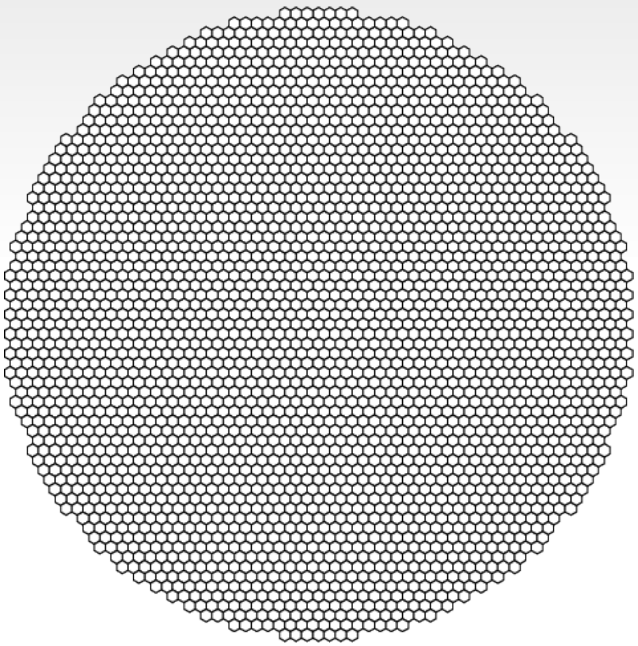
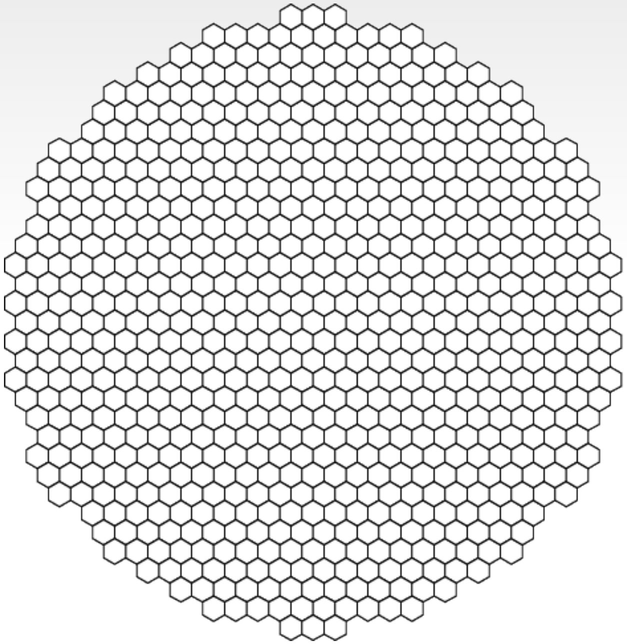




Look-up table



Cone geometry

Pixel layout

Allows easy implementation of the

- Two APD-pixel camera
- Three APD-pixel camera
- Four APD-pixel camera

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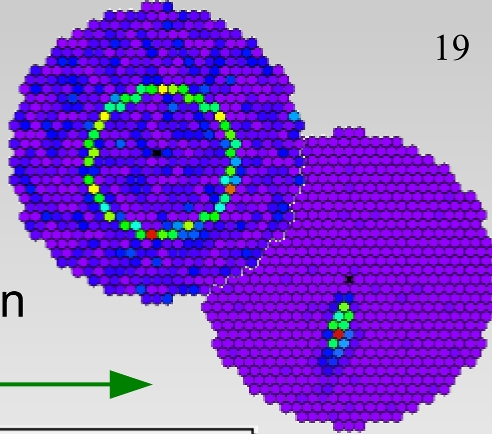

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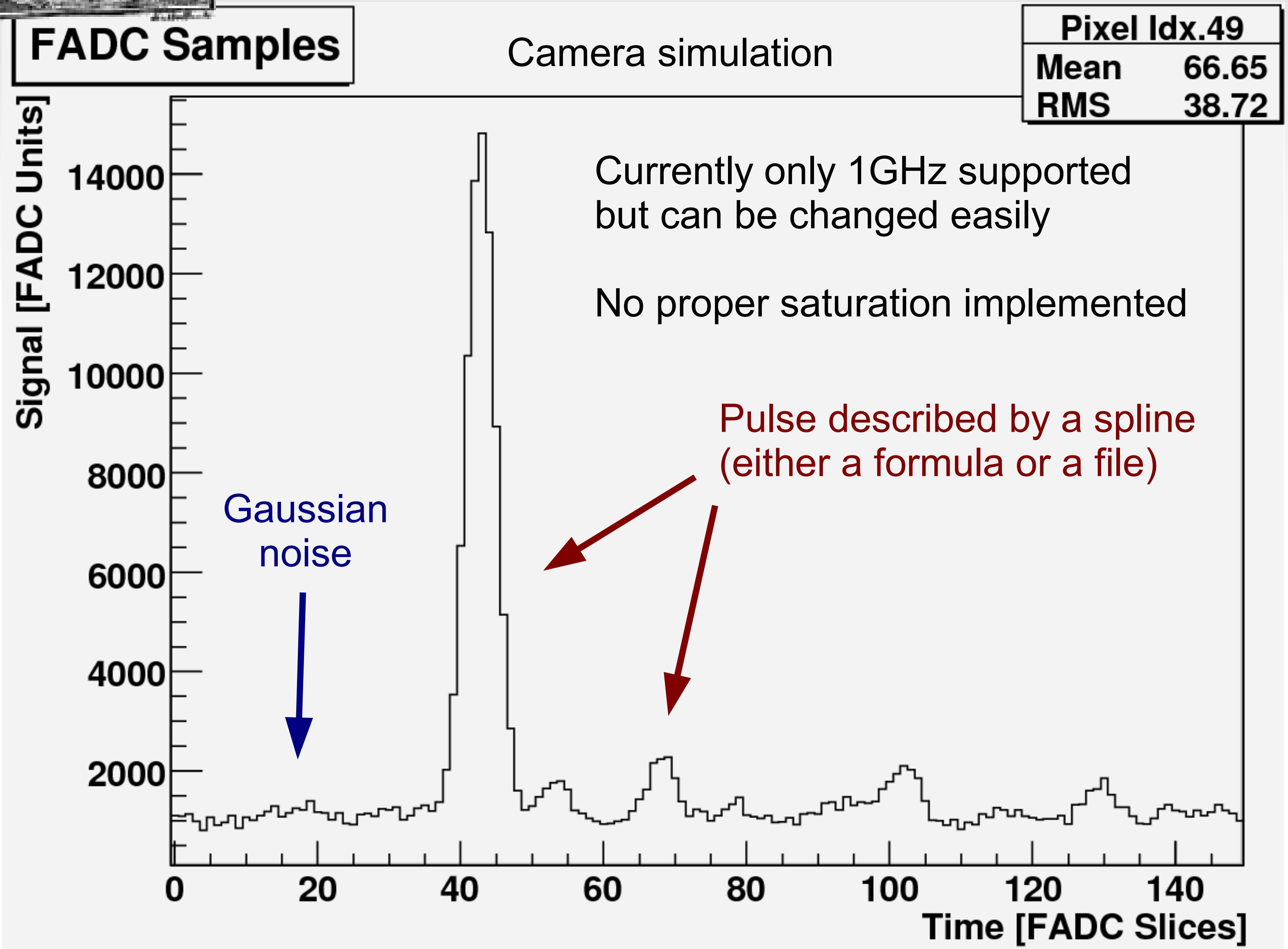

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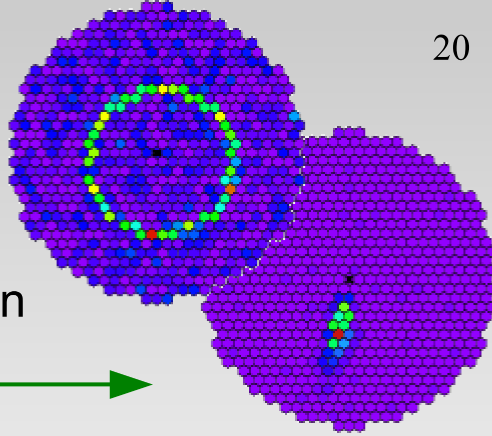

Trigger simulation

Sum the signal of several channels (definition from a look-up table in a file)	e.g. Sum-Pixel layout from M1
↓	
Discriminate the signal analytically using a spline (Fixed or variable length output)	e.g. Fixed length of 8ns
↓	
Check digital channels for coincidences with a minimum overlapping time (definition from a look-up table in a file)	e.g. 2NN, 3NN, 4NN from M1

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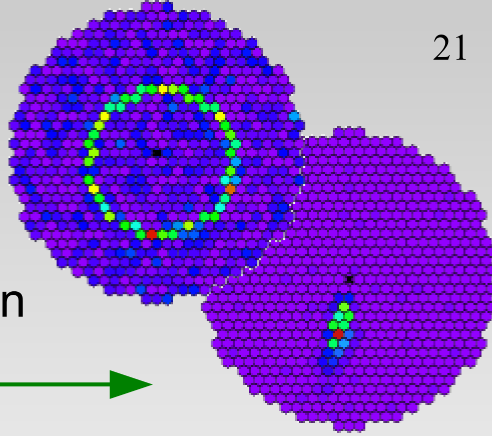

Needs checks or informations

- Expected dark current
- Crosstalk probability (the way crosstalk in simulated!)
- Electronic noise
- DRS response

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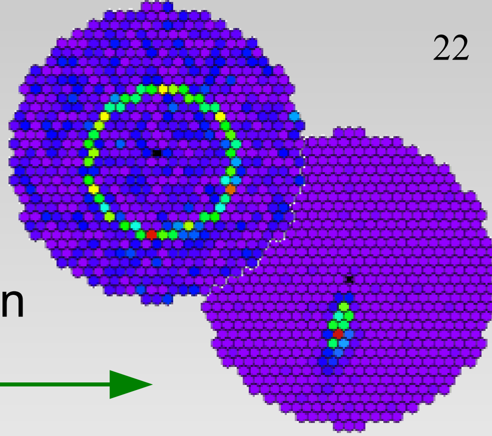

Summary

- Ceres is working well
- Produces output suited for callisto and star
  - Although callisto needs some tuning calibration only in artificial units yet
- Thanks to the modular concept enhancements should be easy

- MAGIC:
  - Still needs some further implementation (e.g. optical link noise)
  - Parameters need some tuning (e.g. trigger, pulse-shape)
  - We should make a little effort to get at least a roughly correct output for a MAGIC detector for our own crosscheck

- DWARF:
  - Parameters need checks and tuning
  - Camera simulation needs ideas to get more realistic (pulse shape, time jitter, time-shifts, trigger jitter, ...)

➔ **Looks promising but needs some manpower**